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Wearable Sensors for Sensing and Communicating Body Functions to a Cell Phone

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Abstract

This poster summarizes the entire process designing and building of senior design project for the senior design course at the University of Southern Maine. This poster gives a brief introduction about the project which is to implement a wearable device to measure and transfer biomedical data of a human to a cell phone app. It consists of implementing a device that can detect and communicate the heartbeats, blood oxygen level, and the skin temperature data of a human. The poster shows the sensors used in the project as well as how each operates. At the end of the poster there are the pictures of the results with the data being discussed and the conclusion taking about the experiences and outlook.

Introduction

The wearable devices in recent years have gained major popularity among people which have led to the designing and building of many wearable sensors across multiple markets. The reason for the popularity of these sensors is mainly due to their convenience and the excessive amount of information and data it provides to consumers. Wearable sensors can be found among many different fields such as medical and fitness markets, but the purpose of these sensors is to provide biomedical data such as body temperature, heartbeat, blood oxygen, EKG, blood pressure, fitness-related measurements and many more.

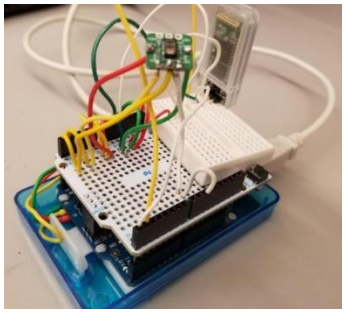
This has motivated us to design and build a device that can measure heartbeat, blood oxygen level, and body temperature, and sends that data via Bluetooth to a cell phone app. For our senior design project at the University of Southern Maine, we are proposing to design and build a wearable device that will take measurements of heartbeats, blood oxygen level and the skin temperature and send it to a cell phone app via Bluetooth. Our design of the device will contain on-shelf sensors such as the heartbeat sensor and the skin temperature sensor.

Materials

There are a variety of products in the market today that have built-in sensors to take measurements such as the apple watch, Samsung devices, Fitbits, etc. But many individual microprocessors can be used with on-shelf sensors to create a device that can take the measurements. The initial task of this project was to research these existing heartbeat measurement sensors, blood oxygen level sensors, and the skin temperature sensor that can be combined with a microprocessor to build a device.

The 700-MAXREFDES117# heartbeat sensor by Maxim is shown above. It measures the heart beats per minute and the blood oxygen level which is known as the Pulse Oximetry reading. To measure the heart rate, first a light shine through the skin and then the sensor measures the amount of light that is reflected from the inside of the finger. The variation in the reflection of the light is interpreted as the heartbeats because it will vary as the blood pulses under the skin pass through the light. For the skin temperature measurements, the TMP36 temperature sensor seen above is used to measure the skin temperature of the human body. The TMP36 temperature sensor can transfer the temperature in Celsius as well as Fahrenheit. The Bluetooth that is used to transfer data from the Arduino Uno to a cell phone app is the Atomic Market HC-06 Bluetooth serial pass seen below. It has the built-in antenna and has the coverage up to 30 ft. Lastly, the most important component for the device, the Arduino Uno microcontroller. The Arduino Uno is programmed using the Arduino Integrated Development Environment (IDE). It operates with 5V and the input voltage is between 7V to 20V. Shown below to the right is the Uno.

Results

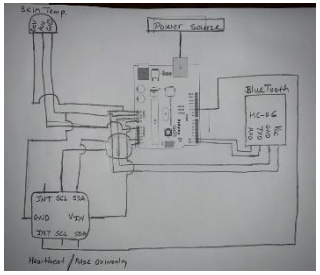


There have been many problems that occurred when trying to make the app in the phone user-friendly. But, in the end, it worked well. The final results of the device gave accurate results frequently. The skin temperature is working very well and it gives accurate results. But, the heartbeat and the blood oxygen level measurements are frequently right, but not accurate. One of the reasons for this is the placement of the finger on the heartbeat sensor. It is very sensitive to the placement of the finger as it emits red light to measure the heartbeat pulse as mentioned in the above sections. If the finger is not covering the light that is being emitted, then it would give wrong results. Also, it is programmed to take 20 rounds of measurements and gives an average of them as a result of the app. Also, the device can only be connected to a smartphone that is operated with Android. This is because the app used to display the data only works with the Android operated phones. The table below shows the few measurements taken by the device.

Iterations	Heart Rate (BPM)	Blood Oxygen Level (%)	Skin Temperature (Celsius/ Fahrenheit)
1	85.50	97.0	27.85/82.13
2	90.0	74.00	28.49/83.28
3	92.75	93.0	27.39/81.31
4	101.75	96.67	28.49/83.28
5	95.33	91.33	27.15/80.87
6	89.0	96.0	28.86/83.94
7	97.75	97.25	27.64/81.75
8	114.75	89.0	27.39/81.31
9	81.33	94.70	28.57/83.43
10	100.25	83.50	23.73/74.21

Conclusion

The purpose of this project was to implement a few wearable sensors to detect and communicate to a cell phone biomedical data of humans. The results obtained from the device shows that it measures the heartbeat accurately when the finger is placed on the device in the right position. It reads the skin temperature roughly 4 to 6 degree Celsius below the normal human skin temperature. This can result from the poor design of the skin temperature sensor or the lack of accuracy of placing the skin temperature on the skin. Also, the blood oxygen level or the pulse oximeter reading is 5% to 8% less than the normal value which is between 95 to 100 %. The heartbeat sensor interprets the variation in the reflection of the light from the finger which can give inaccurate results. This can result from placing the finger improperly on the sensors by not covering the whole area that emits light.



All these issues with sensors lead to inconsistency in the results. Another concern that the device poses in terms of physical constraint is the physical design of the device itself. The device is very large for it to be wearable by the human on hand as it is designed. But, this can be avoided by using different microcontrollers such as the MAX 32630 FTHR - Pegasus Rapid Development Platform, which is much smaller than Arduino Uno and also, it does not require additional Bluetooth. Lastly, the device only works with Android cell phones as the app only works in the Android smartphones, limiting the wide use of it. Overall even though this project ended having some minor issues it was a start that could lead to something more. A lot in terms of teamwork, types of sensors, programming and electrical wiring and soldering was learned leading to a fun and successful project.